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## **Physiological Monitoring During Simulation Training and Testing**

Final Report

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13. ABSTRACT (Maximum 200 words)  The effectiveness of a low fidelity, laptop training simulator has been proven in this study. Military personnel from elite units of the armed forces participated in simulation training prior to conducting real world training at Strategic Operations. Researchers observed, studied and quantified the training transfer that occurred from the laptop simulator to the real world. A series of performance assessment metrics and training effectiveness models were utilized in this study.				
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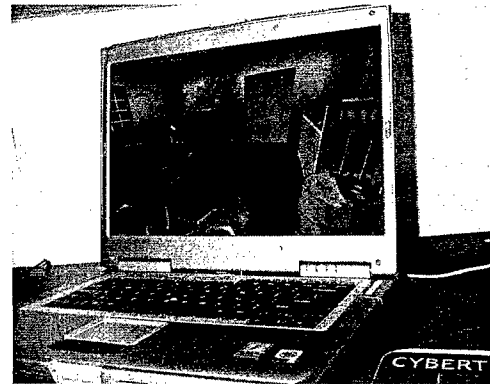
## Introduction

Objectives of the investigation are to examine the effectiveness of virtual reality (VR) training simulators regarding their ability to teach tactical and trauma care skills, to practice stress management techniques (e.g. combat breathing), and to improve performance during real-life combat situations. Participants in the test group will first train in a virtual combat scenario while their stress and arousal levels are monitored through non-invasive physiological means. Participants in the control group will not receive virtual training. Following this, all participants will be tested in a real-world version of this same combat scenario to determine the effectiveness of training in a virtual environment.

State of the art graphics design and software technology have been used in the creation, modification, and testing of the virtual worlds to ensure maximum impact of the training instrument, and cutting edge physiological monitoring technology (Figures 2a, 2b) has been developed and tested to capture and interpret physiological responses to the training and testing scenarios as effectively and efficiently as possible. Virtual worlds of the shoothouse, ship, and Iraqi village (see fig. 3a, 3b, 3c) have been created in 3D to duplicate exactly the training facilities at Strategic Operations.

A Dell Inspiron XPS laptop (fig. 1) which is designed for the game play is used for the virtual training simulators. The following are detailed specifications:

Dell Inspiron XPS Intel Pentium 4 3.4 GHz ,  
15.4 WUXGA with HT Technology  
1GB DDR 400 MHz 2 DIMMs  
128 ATI M Radeon 9700  
60 G Ultra ATA 7200 RPM Hard Drive  
MS Windows XP home Edition  
Modular 4x CD/DVD burner  
Internal Wireless Card (Dell Wireless 1350 (802.11 b/g))



*Dell XPS Laptop (Figure 1)*

The physiological measurements were collected using the J & J Engineering I-330-C2 system. The EEG, ECG, galvanic skin response, temperature, and abdominal respiration sensors were used to collect data.



Figure 2a

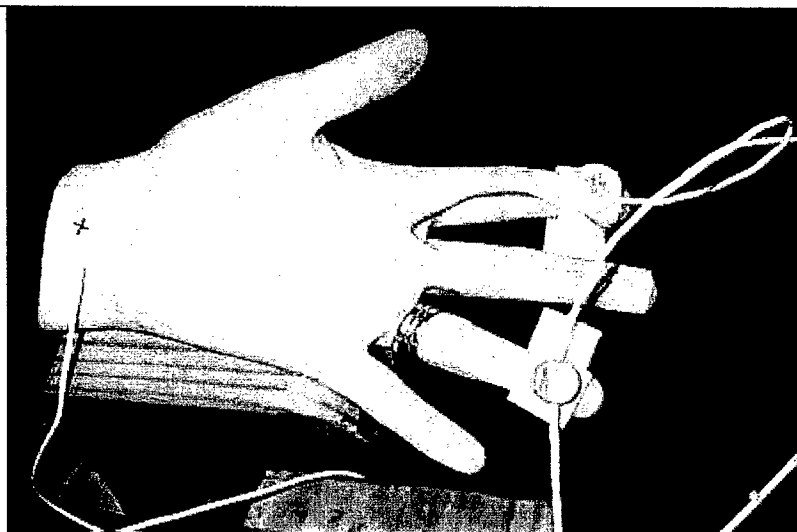


Figure 2b

Subjects were 970 volunteers recruited by the private practice of the Virtual Reality Medical Center (VRMC) and its consultant Strategic Operations. Subjects were a combination of elite units of the United States Navy, United States Marine Corps and the United States Coast Guard. Subject's ages, combat experience, years of service, education and experience with simulators varied.

## 1



Figure 3a

## Virtual Ship

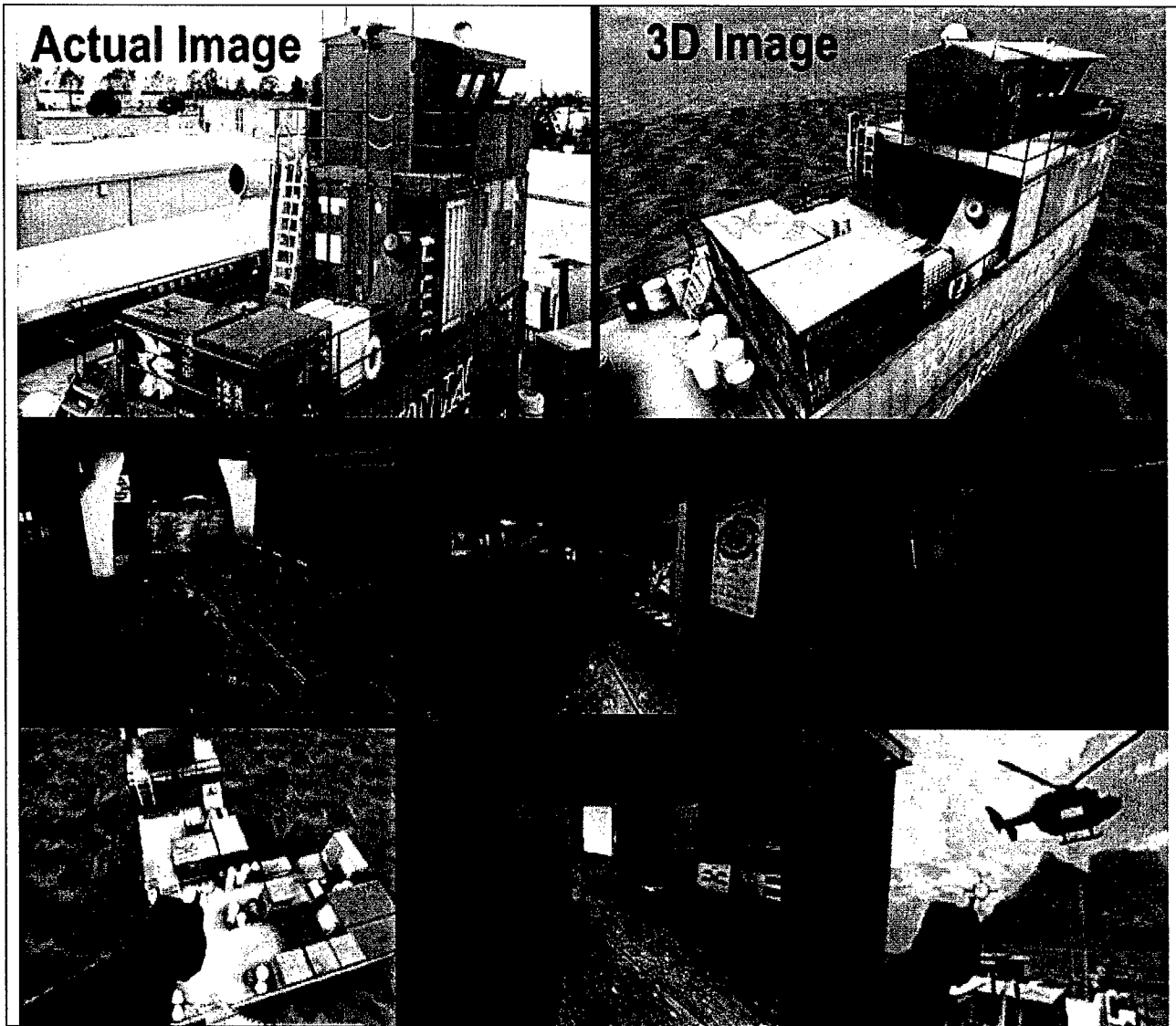
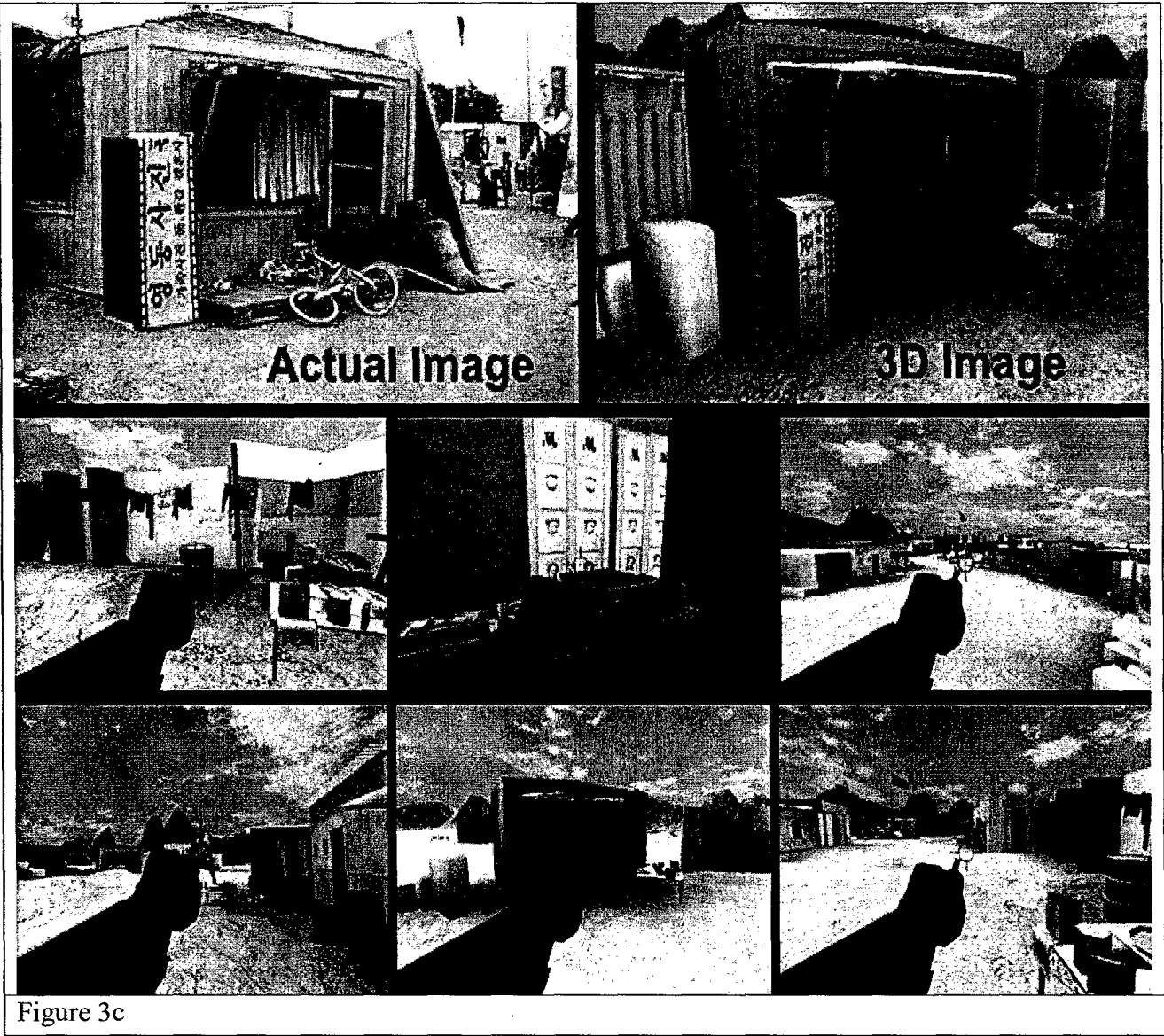


Figure 3b

Virtual Village



This contract pertains to the proposed usage of virtual reality as a training tool for military personnel.

#### **Accomplishments to Date**

We have developed virtual reality simulators for tactical combat and trauma care training. We have recruited and tested participants from the U.S. military, and Coast Guard. We have demonstrated that the virtual environments enhance real world performance through improvements in combat breathing skills, mental preparation, confidence, spatial awareness and navigational abilities.

#### **Difficulties Encountered**

We encountered some difficulty navigating through the virtual "shoothouse". We have fixed the problems by changing the dimensions and location of furniture and by increasing the length of time doors remain in the open position.

#### **Comparison to Plan**

Status achieved is consistent with planned goals for design of the training environment, subject recruitment/running, and data analysis. Resources expended are also consistent with projected amounts.

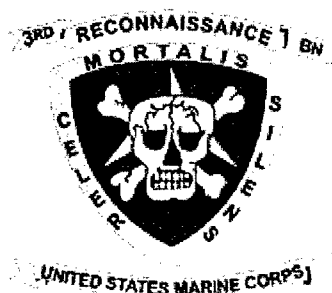
#### **Milestone/Task Status**

Each milestone:

- The project is complete with successful recruitment and running of participants. We have currently tested participants using the virtual shoothouse, village, and ship and analyzed the data.
- Currently, all achieved performance capabilities have met baseline allocations, as all essential software and hardware have been developed, participants have been tested in the virtual environments, and data has been analyzed regarding the effectiveness of the training simulators.
- Effort expended on the task to date includes 1,159 hours of design and preparation by Software Engineers in creating the simulator training scenarios. They have also tested the software for operational compatibility and verified that it is in reliable working order for the training. Additionally, the Graphics Artists have spent 2,022 hours capturing, modifying, and integrating textures to augment and enhance the virtual environments. Investigators have spent 3,292 hours recruiting and testing participants, and completing all governmental requirements necessary for human subject research. Statisticians have spent 773 hours conducting multi-dimensional analyses. The results have been used to improve training protocols and will also be used to confirm any evidence regarding training transfer, states of learning, and virtual reality (VR) performance.

## **Results**

### **USMC 3<sup>rd</sup> Force Reconnaissance Battalion**



The U.S. Marine Corps 3<sup>rd</sup> Force Reconnaissance Battalion under the leadership of Commanding Officer Lieutenant Colonel Daniel Masur participated in VR training and real world training at Strategic Operations. The Alpha, Echo, and Headquarters and Services Companies from this battalion participated in the research. A total of 210 participants were observed during the 11-day training program. Ninety (90) of the 210 subjects received VR training prior to real world training and their performance was compared to the remaining 120 subjects who did not receive VR training. Subjects varied in age, rank, and experience. Ages ranged from 18 to 37 years and subject experience varied between 1 and 17 years. The VR training consisted of the virtual shoothouse and virtual village and was conducted by two research assistants from the VRMC. Real world training was administered by three training officers who recently returned from service in Iraq, Captain John Bahn, Gunnery Sergeant Matt Pranka, and Gunnery Sergeant Eden Pearl. Real world training scenarios were completed in the shoothouse and Iraqi village.





## Marine Corps Training Transfer Exhibited in Shoothouse Exercises

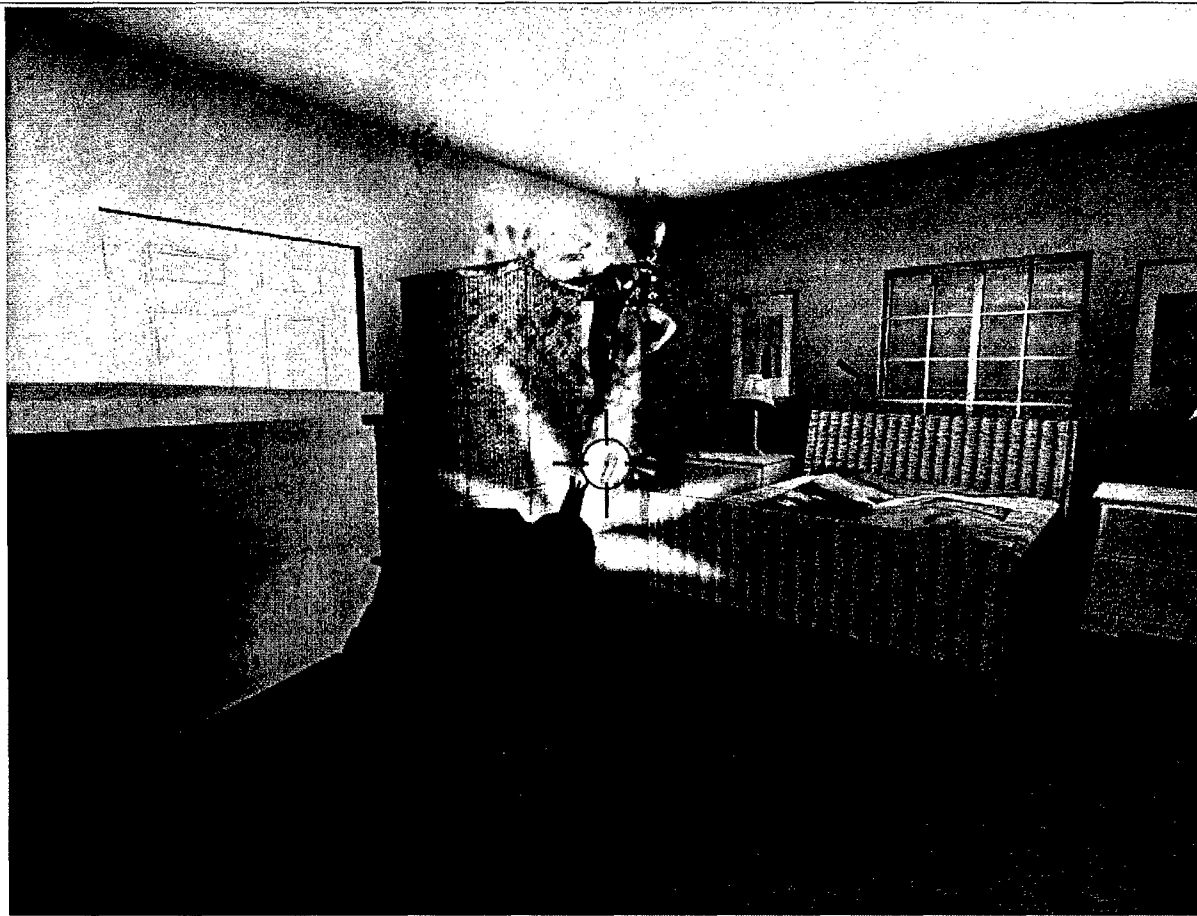


Figure 4

Participants in the VR group (N=90) navigated the virtual shoothouse (fig. 4) with enemies for approximately fifteen minutes (minimum VR exposure was 13 minutes and 23 seconds; maximum VR exposure was 15 minutes and 54 seconds) prior to real world training. Performance in the VR exercises was carefully recorded and subjective feedback was collected after VR exposure. After VR training, the VR group completed real world training exercises along with the 120 subjects who did not receive VR training (non-VR group). All 210 participants (VR and non-VR group) were observed during real world training exercises in the real shoothouse and the performance of each group was evaluated.

The general training goals for the real world shoothouse training exercises involved three phases: (1) taking down and securing the "objective" (shoothouse) as quickly as possible; (2) conducting a sensitive site exploitation; and (3) exfilling the crisis sight. Every exercise focused on the efficient and systematic completion of several discrete tasks, which were observed and critically evaluated during each training scenario. These specific tasks are outlined below.

- I Taking Down the Objective
  - a. Set up external security
  - b. Breach the door to the shoothouse
  - c. Identify danger areas
  - d. Locate and identify all rooms of the shoothouse
  - e. Clear each room
  - f. Secure the objective

- II Conducting a Sensitive Site Exploitation (SSE)
  - a. Sketch the house
  - b. Identify contraband, weapons, or other significant materials
  - c. Search hostile and unknown personnel
  - d. Determine appropriate course of action

### I. Taking Down the Objective

#### A. Set Up External Security

Example Scenario: Subjects are to establish and maintain external security while the assault element is in the objective.

Task Objectives: 1) Quickly and quietly dismount the vehicle piece; 2) fan out and establish a foothold around the objective; and 3) maintain its integrity until mission in the objective is complete.

Tactic, Technique, Procedure (TTP): Tactic – Security element; Technique – Pie off and pick up danger areas, use buddy system; Procedure – Push out and gain a strong foothold around the objective

Non-VR Group Performance: Training officers indicated that subjects found poor cover (behind propane tanks), were too spread out, and individuals drifted too far from the objective. Subjects often left their backs exposed and on one occasion, one subject took up a position directly down range from the SAW gunner. The perimeter was permeable at times, as subjects did not control local personnel from walking in and out of the boundary.

VR Group Performance: Training officers noted that subjects found good cover and maintained a tight impermeable security perimeter. Subjects were more aware of what was behind them and did not obstruct the range of the SAW guns. In general, verbal communication was kept to a minimum and movements of team members were quick and coordinated.

Discussion: Findings indicate that VR training improved subjects awareness of what was behind them, which enabled them to remain better protected throughout the task. The VR-trained group was also better at personnel placement, which may be due to enhanced spatial awareness learned from VR training. Performance data also suggests that VR training facilitated teamwork.

#### B. Breach the Door

Example Scenario: Subjects must take down the insurgents' strong hold. There are numerous objects placed in front of the entrance to the objective and the breach point has two doors that are heavily secured with chains and other reinforcing materials. The outer door is metal while the inner door is wood.

Task Objectives: (1) Quickly and quietly approach the breach point; (2) identify the breach point, what tools are needed, what personnel are needed, which way the door opens, where to place personnel; (3) breach and enter the objective; and (4) remain concealed from enemy fire.

TTP = Tactic, Technique, Procedure: Tactic – Breacher and shooter team; Technique – Mechanical breach; Procedure – Breacher will use appropriate tools to breach objective and shooter will clear the "fatal funnel" while leading the 5-man teams into the objective

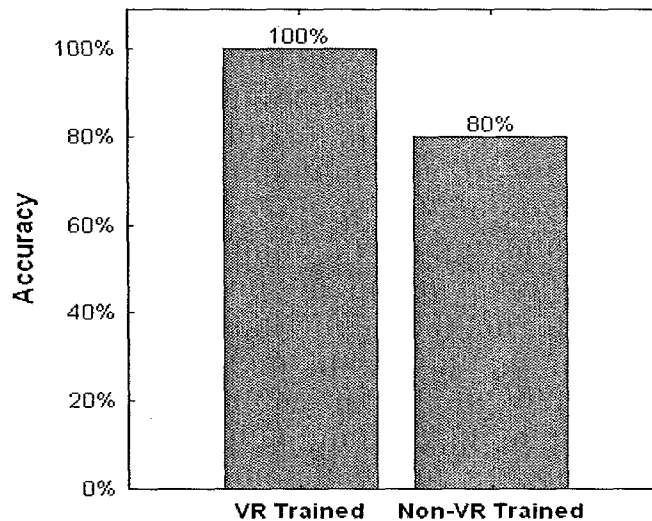
Non-VR Group Performance: Subjects properly identified the outward opening door 72.2% of the time. Subjects used the correct tool for breaching the door 80% of the time (e.g. hooligan, c4 explosives, shotgun, and sledgehammer).

VR Group Performance: Subjects identified the outward opening door in every exercise (100% of the time). Subjects utilized the correct breaching tool 100% of the time.

Discussion: Overall, training officers indicated that the VR group exhibited superior performance of this task by executing the drill more efficiently with more organized and secure movements. The VR group identified the outward opening door 27.8 % more effectively, which enabled teams to complete the task more quickly. The non-VR teams that did not recognize the outward opening door became stacked at the entrance to the shoothouse, which made them vulnerable to hostile fire. The VR group utilized the correct tool 20% more often than the non-VR group, which enabled the VR-trained teams to complete the drill more efficiently. The increased efficiency of the VR teams also improved their momentum while entering the shoothouse, which helped in taking down the objective. In contrast, the non-VR-trained teams lacked momentum upon entering the house. This compromised the element of surprise and encumbered their ability to efficiently take down the objective. Results indicate that the VR training improved task performance by teaching subjects about the features of the door and the spatial layout of the entrance to the shoothouse. The VR training also promoted greater team organization and enabled teams to adjust more efficiently to new information and/or obstacles.



Proper ID & Breach Technique



### C. Identify Danger Areas

**Example Scenario:** Danger areas are classified as places that have not been cleared or secured. They exist in all exercises and can appear/disappear throughout a scenario.

**Non-VR Group Performance:** Training officers reported that subjects exhibited satisfactory identification of danger areas in the shoothouse. Subjects were proficient at identifying doors and windows, but were not alert to concealed areas and hidden rooms. In addition, participants were not aware of the dangers and danger areas in the hallway. Training officers also indicated that subjects appropriately responded to danger areas about 60 % of the time.

**VR Group Performance:** Training officers reported that subjects exhibited a "slightly improved" performance, compared to the non-VR group. Subjects were more aware of hidden rooms and were better at recognizing dangers in the hallway and appeared to be more vigilant to danger areas. Training officers also established that subjects appropriately responded to danger areas about 70% of the time.

**Discussion:** Our qualitative data suggests that the VR-trained group was better at identifying and responding to danger areas. Training officers noted that the group without VR training carried injured personnel through danger areas, thus exposing more subjects to hostile fire and potential injuries. The VR-trained group did not exhibit this error. Results indicate that as a result of VR training, the VR group was more aware of threatening scenarios and thus, better prepared to respond to dangerous situations.

### D. Locate and Identify Rooms

**Example Scenario:** Subjects must enter the shoothouse and quickly locate all rooms. The house contains three bedrooms and one living room. All three bedroom doors are closed and the living room does not have a door. There is a hostile gunman in the last room, farthest from the entrance. There is also an unarmed unknown male in the first room on the right.

**Task Objectives:** (1) Quickly locate, enter, and clear all rooms; (2) identify danger areas while following point man's lead; and (3) identify, engage, and take out hostiles.

**TTP:** Tactic – 3 teams of 5 men; Technique – Subdued entry; Procedure – Move quietly up to the room and enter with violence while minimizing time spent in the hallway

**Non-VR Group Performance:** During scenarios that used 4 rooms, it took subjects an average of 2 minutes and 43 seconds to locate all 4 rooms. Out of 32 trials, 5 exercises resulted in one missed room (84.4% accuracy). Training officers indicated that upon first entering the house, teams spent too long in the hallway. A quantifiable statistic for this measure was not collected; as it is still being developed (we believe we can acquire this data from the videotaped footage).

**VR Group Performance:** During scenarios that used 4 rooms, it took subjects an average of 2 minutes and 37 seconds to locate all 4 rooms. Out of 35 trials, 2 exercises resulted in missed rooms (94.3% accuracy).

**Discussion:** Training officers assessed that the VR groups moved more quickly into the first room upon entering the shoothouse, thus reducing the amount of time spent in the hallway. Communication was minimal as each person was

able to anticipate the other/team movements. The hallway is where a large majority of casualties occur and thus, reducing time spent in the hallway is a vital life saving tactic. The VR group took, on average, six seconds less to locate all 4 rooms. In addition, the VR group was 9.9% more accurate in locating all 4 rooms. These measurements suggest that VR training is an important tool for teaching participants about the placement of the rooms and corridors, which enable subjects to locate rooms quickly and move through the hallway more effectively. Additionally, the VR training enabled subjects to develop a mental image of the objective (shoothouse) before entering the real house and thus, the VR group was better prepared to locate and identify rooms.

#### E. Clear Rooms

Example Scenario: Teams enter one room to conduct a detailed search. The front door is open in this scenario.

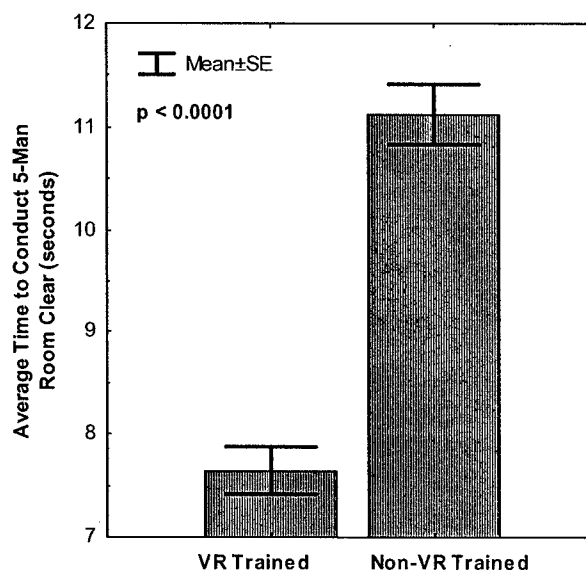
Task Objectives: (1) Enter the room; (2) scan the room for people and hiding places; (3) conduct a detailed search; and (4) place green chemical light on door way at eye level to indicate that the detailed search is complete.

TTP: Tactic – Force Recon Platoon; Technique – One team of 5 men will clear the room in the following fashion: the point man will strong point while the first person will clear to the deep corner, the 2<sup>nd</sup> person will clear in the opposite direction and the 3<sup>rd</sup> will clear in the opposite direction of the 2<sup>nd</sup>, etc.; Procedure – Clear and search the room top to bottom and counterclockwise

Non-VR Group Performance: A 5-man team took an average of 11 seconds (averaged over 60 trials) to clear 1 room.

VR Group Performance: A 5-man team took an average of 9 seconds to clear one room (averaged over 60 trials).

Discussion: On average, the VR group completed the room clearing task 2 seconds faster than the non-VR group. In addition, assessors noted that the non-VR group exhibited poor personnel placement throughout the task by leaving their backs exposed and unprotected. Often times, there was too much talking in attempts to organize the team. Findings suggest that the VR training improved the speed and efficiency of this task by teaching subjects about the placement of doors, windows, and objects in the room, which enabled them to calculate their movements before executing the real exercise.



#### F. Secure the Objective

Example Scenario: Teams must enter an affluent Sheikh's house and conduct a detailed search for weapons. The number, location, and intentions of the house inhabitants are unknown.

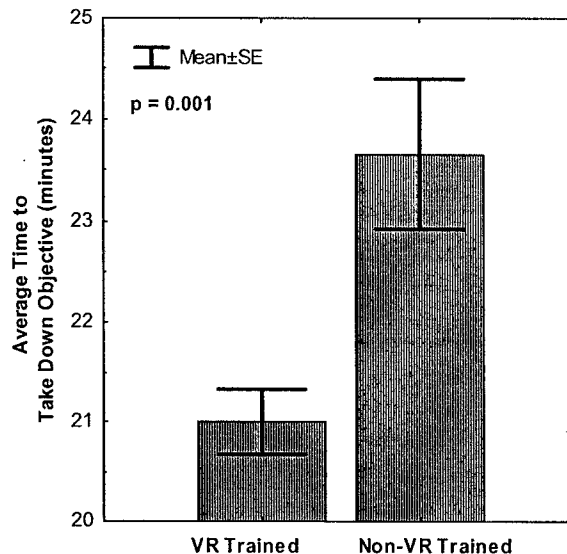
Task Objectives: 1) Set up external security around the objective; 2) breach and enter the objective; and 3) clear all rooms and secure the objective.

TTP: Tactic – Force Recon Platoon; Technique – There are three elements working in coordination: the security element, the breacher and shooter element, and the assault element; Procedure – Establish perimeter around the objective, breach objective, and clear rooms and danger areas

Non-VR Group Performance: Initial calculations indicate that subjects took an average of about 23 minutes to secure the objective (averaged over 32 trials). For all trials, all the rooms were located and cleared successfully, but 2 exercises resulted in teams clearing rooms multiple times (93.8% accuracy).

**VR Group Performance:** Initial calculations indicate that subjects took an average of about 21 minutes to secure the objective (averaged over 35 trials). For all trials, all the rooms were located and cleared successfully and no rooms were cleared multiple times (100% accuracy).

**Discussion:** Initial findings indicate that the VR-trained group secured the objective about 2 minutes faster than the group without VR training. The VR group also exhibited a 6.2% increase in accuracy when clearing rooms, as they did not clear rooms multiple times. Results indicate that the VR training improved performance by enabling subjects to develop a mental map of the shoothouse before entering the real objective. Consequently, the VR group was already familiar with the spatial layout of the house before the real task and thus, better prepared to execute the drill. Findings also suggest that the VR training promoted teamwork and improved teams' ability to remain organized while adapting to new scenarios.



## II. Conducting a Site Sensitive Exploitation

### A. Sketch the House

**Example Scenario:** After securing and searching the Sheik's house, teams must conduct an SSE of the objective.

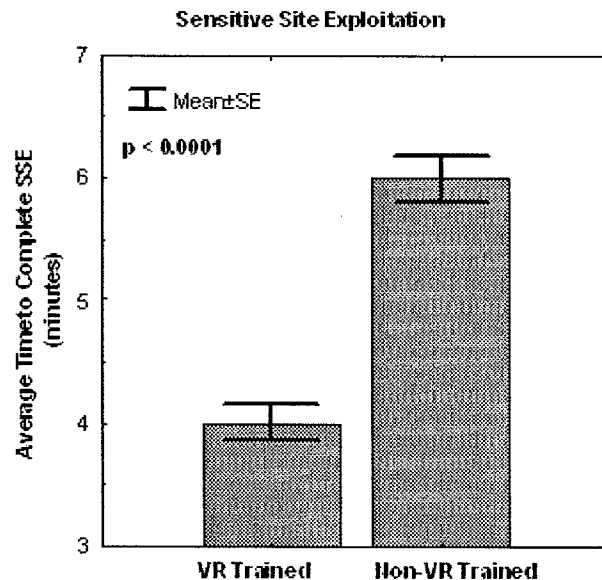
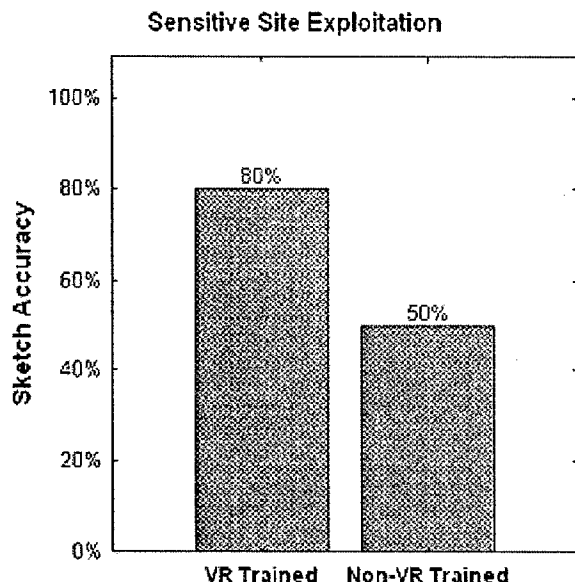
**Task Objectives:** (1) Draw an accurate sketch of the layout of the shoothouse; (2) catalogue significant objects found in the objective; and (3) mark locations of the materials on the house layout

**TTP:** Tactic – 2-man SSE team; Technique – Conduct a detailed search so that nothing goes untouched, one person will sketch while the other person collects significant materials in a duffle bag; Procedure – Start at breach point and begin sketching the house from the front to the back and counterclockwise

**Non-VR Group Performance:** Subjects exhibited 50% accuracy with this task. This score was calculated based on the number of correctly identified and placed objects (rooms, objects, and people) divided by the total number of objects. Training officers observed that most sketches lacked detail. Initial calculations demonstrate that subjects took an average of about 6 minutes to complete the sketch.

**VR Group Performance:** Subjects exhibited 80% accuracy with this task. Compared to the non-VR group, training officers determined that sketches exhibited greater detail. Initial calculations indicate that subjects took an average of about 4 minutes to complete the sketch (averaged over 35 trials).

**Discussion:** On average, the VR-trained group completed shoothouse sketches 2 minutes faster than the non-VR group. The VR group's sketches were 30% more accurate and exhibited greater detail than the non-VR group. Findings suggest that the VR training was a useful tool for teaching participants about the placement of rooms and objects in the shoothouse, which enabled them to draw more accurate and detailed sketches of the objective. The data also indicates that the VR training improved the completion time of this task.



### B. Identify Contraband, Weapons and Other Significant Materials

**Example Scenario:** After securing and searching the Sheik's house, a weapon is found in the bedroom that must be identified.

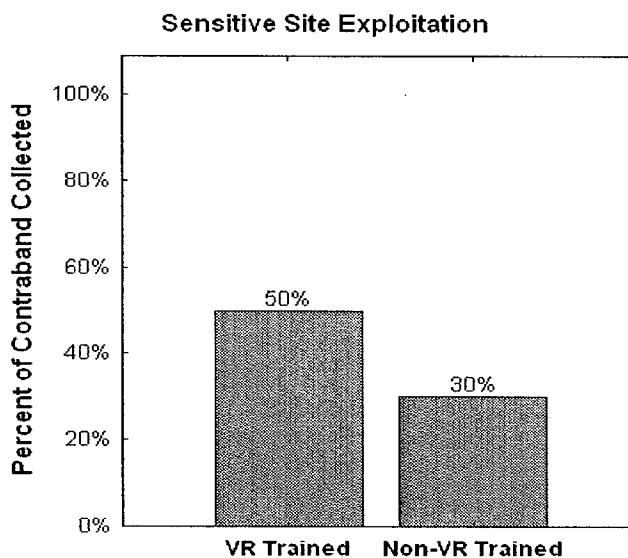
**Task Objectives:** (1) Check to see if weapon is rigged; (2) identify type of weapon; (3) disarm and secure weapon; and (4) wait for SSE team to document the weapon.

**TTP:** Tactic – Force Recon Platoon; Technique – 5 man team with SSE team; Procedure – Locate significant materials and disarm weapons while waiting for SSE team

**Non-VR Group Performance:** Subjects correctly identified and confiscated 30% of contraband, weapons and other significant materials. This percentage was calculated by dividing the number of correctly identified materials by the total number of target materials for each trial and then averaging the scores from each trial (total of 32 trials).

**VR Group Performance:** Subjects correctly identified and collected 50% of contraband, weapons, and other significant materials hidden throughout the house. This value was calculated as an average of 35 trials.

**Discussion:** On average, the VR group identified and confiscated 20% more significant material than the non-VR group. These results suggest that the VR training taught subjects to more efficiently locate hiding places and concealed locations where significant materials might be placed.



### C. Locate and Search Hostiles and Unknown Personnel

Example Scenario: After securing and searching the Sheik's house, teams found 1 unknown man and 1 unknown female. Neither person took fire or had any illegal materials in their possession.

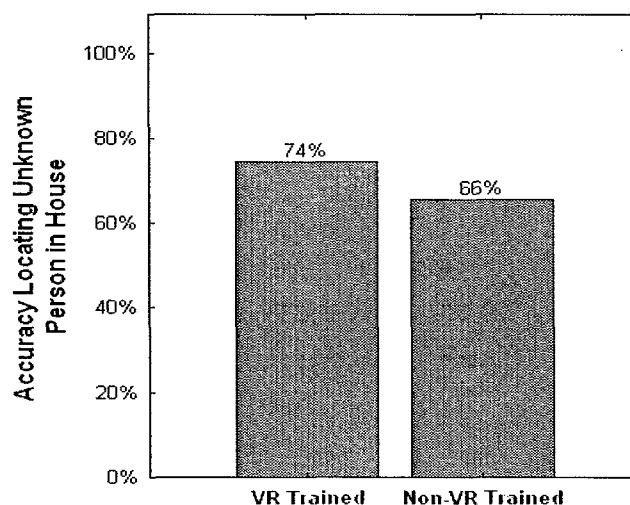
Task Objectives: (1) Locate unknowns; and (2) use escalation of force while interacting with unknowns.

TTP: Tactic – Force Recon Platoon; Technique – 3 teams of 5 men; Procedure – Use escalation of force and flex cuff all individuals, separate males and females, place unknowns standing facing the wall with their forehead touching the wall and legs spread, search unknowns top to bottom starting down the left side and then the right

Non-VR Group Performance: Out of 32 trials, subjects failed to locate unknown personnel 11 times, resulting in 66% accuracy.

VR Group Performance: Out of 35 trials, subjects failed to locate unknown personnel 9 times, resulting in 74% accuracy.

Discussion: The VR-trained group located unknown personnel 8% more accurately than the non-VR group. This measurement suggests that the VR training taught participants to search rooms more thoroughly and locate hiding places more efficiently.



### D. Determine Course of Action

Example Scenario: After securing and searching the Sheik's house, an IED was discovered in a bedroom with wires attached. It appears to be rigged.

Task Objectives: (1) Determine appropriate course of action; and (2) deliver orders.

TTP: Tactic – Force Recon Platoon; Technique – 5-man team; Procedure – Mark the location of object in the house and call the EOD (explosive ordinance disposal) before evacuating the house immediately

Non-VR Group Performance: Training officers indicated that subjects chose the correct course of action the majority of the time, but were slow in determining the appropriate act.

VR Group Performance: Training officers noted that participants made quicker decisions and adapted better to unknown scenarios and obstacles compared to the non-VR group.

Discussion: Qualitative statistics suggest that VR training helped participants make quicker decisions when determining the proper course of action. Feedback from the training officers suggests that VR training promoted critical thinking skills and improved participants' ability to adapt to unknown and/or challenging situations.

Participants in the VR group (N=90) navigated the virtual village (Fig. 5) with enemies for approximately fifteen minutes (minimum VR exposure was 14 minutes and 18 seconds; maximum VR exposure was 15 minutes and 22 seconds) prior to real world training. Performance in the VR exercises was carefully recorded and subjective feedback was collected. After VR training, the VR group completed real world training exercises along with the 120 subjects who did not receive VR training (non-VR group). All 210 participants (VR and non-VR group) were observed during real world training exercises in the real village and the performance of each group was evaluated.

- I. Urban Movements, Warfare and Tactics
  - A. Cover and concealment
  - B. Assessment and triage of wounded
  - C. Exfil



## I. Urban Movements, Warfare, and Tactics

### A. Cover and Concealment

Example Scenario: A field interrogation of a local affluent sheik is being conducted when a platoon suddenly becomes ambushed by RPG's and AK 47 fire.

Task Objectives: (1) Return fire; (2) locate areas to take cover; and (3) protect and evacuate sheik

TTP: Tactic – Security detail; Technique – Leap frog in front of detail and keep locals away from sheik; Procedure – Using buddy system, pie off and pick up danger areas, clear obstacles and move stealthily through urban environment

Non-VR Group Performance: Training officers indicated that the non-VR group repeatedly exposed themselves to danger areas and were slow in finding cover. During one episode, subjects erroneously found cover behind propane tanks. During several exercises, subjects were lured into the open street by the locals. The sheik was safely extracted 70% of the time.

VR Group Performance: Training officers indicated that the VR group used corners and walls more effectively to conceal themselves from enemy fire. Subjects barricaded themselves in positions where they could maximize fire power down range. In addition, subjects found cover quickly after the explosion of an RPG. The sheik was safely extracted from the village 90% of the time.

Discussion: Results suggest that the VR training was an effective tool for teaching participants where to find cover. The VR-trained group remained concealed longer and located cover more quickly, which increased their chances for survival. Findings also suggest that the VR training improved participants' ability to turn corners and use walls as protection. In regards to evacuating the sheik, the VR group accomplished this task 20% more successfully than the non-VR group.

### B. Assessment and Triage of Wounded

Example Scenario: While teams are searching and securing a small Iraqi village, they encounter hostile fire and engage the enemy in a fire fight. During the operation, a soldier loses his leg from an RPG that exploded in a back street of the village.

Task Objectives: 1) Locate the wounded soldier; 2) recover the wounded soldier while protecting self; and 3) evacuate the wounded soldier

TTP: Tactic – Force Recon Platoon; Technique – Eliminate immediate threat and pull out any casualties, leave nobody behind; 3) Procedure – Call for Medivac, survey the situation and establish cover teams, determine if the wounded soldier is being used as a trap, maximize fire power and overwhelm the area with force while retrieving wounded

Non-VR Group Performance: Training officers indicated that subjects often exposed themselves to hostile fire while attempting to recover the wounded. In three of the exercises, two participants died from an RPG while attempting to collect the wounded soldier.

VR Group Performance: Training officers indicated that participants practiced more caution in recovering the wounded soldier. Subjects exhibited increased awareness of potential traps and were more organized when attempting to collect the wounded.

Discussion: Results suggest that the VR training promoted team organization and increased awareness of potential traps.

### C. Exfil

Example Scenario: The Iraqi village has been secured and the team must get back to the base.

Task Objectives: 1) Establish security for evacuation; 2) gather everyone back onto vehicle piece; and 3) maintain security.

TTP: Tactic – Force Recon Platoon; Technique – Establish security while team gathers around vehicle and remain holding a secure position until it is your turn to fold out; Procedure – Personnel farthest from vehicle will fold out first and will tap the remaining personnel as they fold out, one person will piece count all men to make sure everyone is accounted for

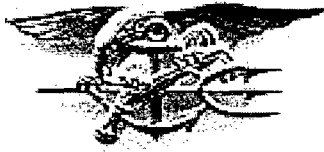
Non-VR Group Performance: Training officers indicated that participants were slow to recognize the proper opportunity to begin exfil. Participants were unorganized in finding the humvee and often left secure locations too early. In other exercises, the team was too slow to fold out and the humvee left without the whole team.

VR Group Performance: Training officers indicated that participants demonstrated better decision making regarding when to begin exfil. In addition, the exfil was more organized and more efficient.



Discussion: Data suggests that VR training is a beneficial tool for improving team organization during exfil procedures. The VR training can be used to practice “folding out” of the objective to increase the quality and efficiency of execution in the real world scenario.

## U.S. Navy SEAL Team 7



The United States Navy SEAL Team Seven under the command of Commander Tucker participated in VR and real world training at Strategic Operations. The Foxtrot and Delta platoons participated in the research. Ages ranged from 20 to 36 years and subject experience varied between 0 (just graduated from BUDS) and 12 years. Thirty (30) out of the 90 on the team received VR training using the virtual shoothouse and village prior to real world training exercises. The VR training was administered on a laptop computer by a research assistant from the VRMC. Real world training was administered after VR training by Lieutenant Blintz and LCPO Swartz. Real world training exercises were completed in the shoothouse and Iraqi village.

### Navy SEAL Training Transfer Exhibited in Shoothouse Exercises

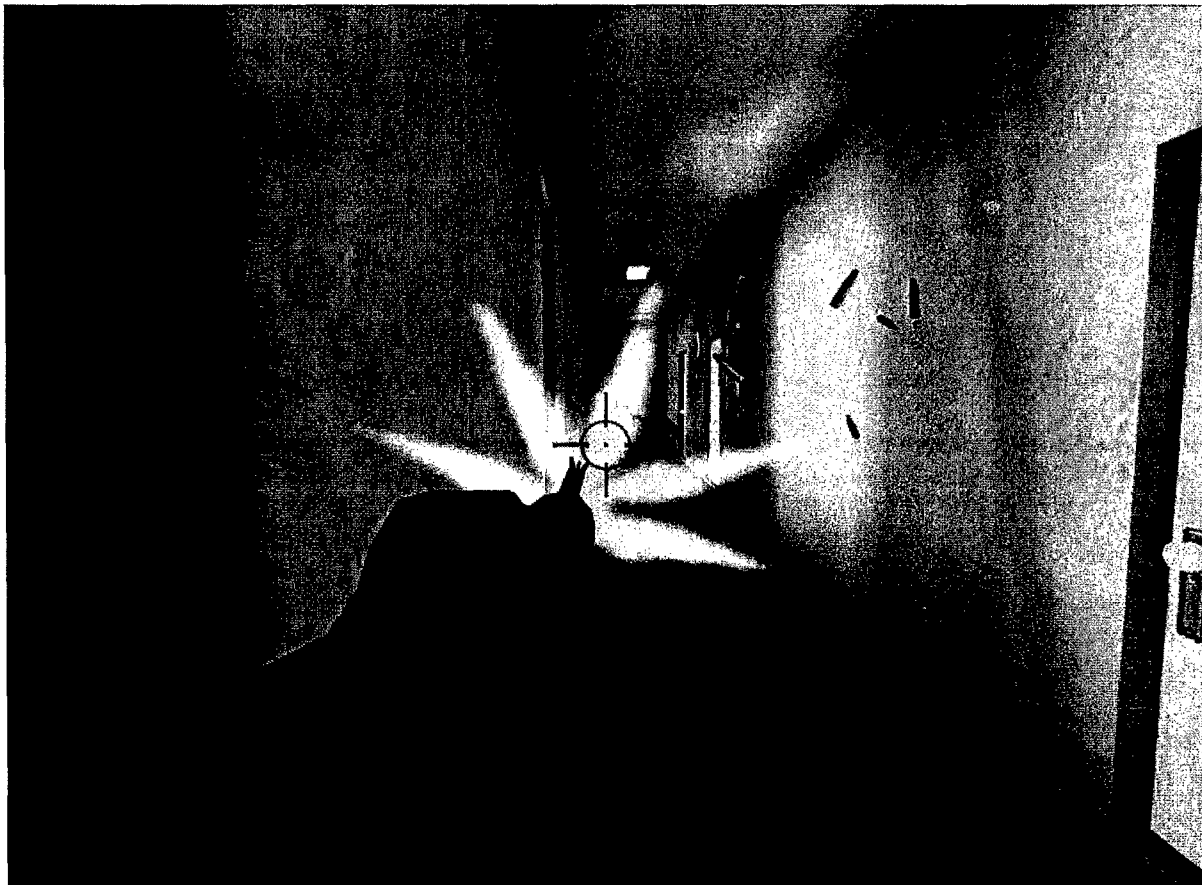


Figure 6

Participants navigated the virtual shoothouse (Fig. 6) with enemies for approximately fifteen minutes (minimum VR exposure was 13 minutes and 37 seconds; maximum VR exposure was 15 minutes and 40 seconds) prior to real world training. Performance in the VR exercises was carefully recorded and subjective feedback was collected. After VR training, the VR group completed real world training exercises in the shoothouse and their performance was critically evaluated by a research assistant from the VRMC and LCPO Swartz. Data from the VR-trained group was compared to performance data from previous Navy SEAL groups who completed the same real world training exercises, but did not receive VR training.

The general training goals for the real world shoothouse training exercises involved three phases: (1) taking down and securing the "objective" (house) as quickly as possible; (2) conducting a detailed search of the house and inhabitants; and (3) exfilling the crisis sight. Every exercise focused on the efficient and systematic completion of several discrete tasks. These specific tasks are outlined below.

#### I. Taking Down the Objective

- a. Breach the door to the shoothouse
- b. Locate and identify all rooms of the shoothouse
- c. Clear rooms

#### II. Detailed Search

- a. Process unknowns
- b. Search rooms

### I. Taking Down the Objective

#### A. Breach the Door

Example Scenario: Subjects must take down a terrorists' house by first breaching the entrance. The entryway consists of 2 doors that are secured by chains and other various materials.

Task Objectives: 1) Quickly and quietly approach the breach point; 2) identify the door; and 3) breach and enter the objective.

TTP: Tactic – Breacher and shooter team; Technique – Mechanical breach; Procedure – Breacher will use a hooligan and a sledgehammer to open the door and the shooter will lead the four 2-man teams into the objective

VR Group Performance: On average, subjects breached and entered the objective quickly and the stack broke off into teams with little confusion. Training officers noted that in most exercises, subjects properly identified the hinges on the outside door and were aware of the front windows during entry.

Discussion: Training officers noticed that the VR-trained group demonstrated better task organization as they rode the breach into the objective, compared to non-VR-trained teams. Teams without VR training were observed stacked in the hallway and confused as to where their teammates were headed. Data suggests that the VR training improved team organization and enhanced real world performance by instructing subjects about the nature of the breach point and making them more aware of surrounding dangers (e.g. windows, hallways, and doors).

#### B. Locate and Identify Rooms

Example Scenario: The house contains three bedrooms and one living room. All three bedroom doors are closed and the living room does not have a door. There is a hostile gunman in the last room farthest from the breach point and one unarmed unknown in the first room to the right.

Task Objectives: 1) Locate and clear all rooms.

TTP: Tactic – Subdued entry; Technique – Enter as a stack and break off into four 2-man teams; Procedure – Move quietly to the room and enter aggressively and violently

VR Group: Subjects displayed outstanding task organization as they appropriately identified every room (100% accuracy). No rooms were cleared twice and traffic in the hallways flowed smoothly. All hiding areas and hidden compartments were uncovered.

Discussion: Training officers noted that VR-trained teams exhibited more coordinated movements and better search techniques than non-VR groups. VR groups displayed systematic and calculated movements through the objective that non-VR-trained groups lacked. In addition, VR groups accurately located rooms and hiding areas better than non-VR groups. Subject interviews revealed that many participants felt more alert and aware of hidden rooms as a result of the VR training. Additionally, subjects commented that they were able to rehearse different scenarios and



test new tactics using the virtual trainer, which provided them with more confidence in executing the real world exercise. Findings suggest that VR training improved task performance by teaching them about the spatial layout of the house and allowing them to practice their movements.

### *C. Clear Rooms*

Example: A 2-man team enters a single room and must clear it of all dangerous contents.

Task Objective: 1) Enter and clear room.

TTP: Tactic – SEAL Platoon; Technique – 2-man clear; Procedure – The 1<sup>st</sup> man clears the deep corner and the 2<sup>nd</sup> man moves opposite the 1<sup>st</sup> man

VR Group: Teams operated cohesively and effectively executed the task. Training officers noted that teams used minimal verbal communication.

Discussion: VR-trained subjects showed confidence and proficiency in this task. Training officers indicated that the VR groups exhibited superior personnel placement within the room, compared to non-VR-trained teams (e.g. the VR teams were able to position themselves so that all corners were cleared without flagging their partner). Feedback revealed that the VR training helped participants execute the real task more effectively by allowing them to plan their movements. This practice enabled subjects to anticipate the movements of their teammate and accomplish the task more efficiently.

## **II. Detailed Search**

### *A. Process Unknowns*

Example: One (1) male and one (1) female unknown are found in a house with a weapons cache.

Task Objective: 1) Secure, extract and bring back unknown personnel/property for processing.

TTP: Tactic – SEAL Platoon; Technique – 2-man team; Procedure – One man holds security on the unknown while the other man flex cuffs and searches the unknown

VR Group: Training officers indicated that subjects handled unknowns with the proper escalation of force and appropriately placed the male and female into different rooms before beginning the field search.

Discussion: Training officers noted that VR participant performance was more consistent and systematic than non-VR participant performance. Non-VR groups did not always face the unknowns towards the wall and sometimes placed the unknowns in the same room. Findings suggest that the VR training instructed subjects to execute tasks in a systematic and regimented pattern. The VR training taught participants a general scheme for conducting detailed searches and subjects were able to generalize this method and effectively apply it to a variety of scenarios.

### *B. Search Rooms*

Example: The objective is secured and teams must conduct a detailed search of each room.

Task Objective: 1) Efficiently search and secure each room in the house.

TTP: Tactic – SEAL Platoon; Technique – 2-man teams, Procedure – Search the rooms from top to bottom and left to right, touch everything

VR Group: Subjects exhibited consistent execution and searched each room efficiently.

Discussion: VR-trained subjects were more systematic in their execution of this task. Training officers revealed that VR-trained subjects exhibited an increased attention to detail, compared to non-VR-trained subjects. Findings suggest that VR training improved real world performance by helping subjects develop a cognitive map of the house, which improved search accuracy and completion speed.



## Navy SEAL Training Transfer Exhibited in Iraqi Village Exercises



Figure 7

Participants navigated the virtual village (Fig. 7) with enemies for approximately fifteen minutes (minimum VR exposure was 14 minutes and 18 seconds; maximum VR exposure was 15 minutes and 22 seconds) prior to real world training. Performance in the VR exercises was carefully recorded and subjective feedback was collected. After VR training, the VR group completed real world training exercises and their performance was critically evaluated by a research assistant from VRMC and LCPO Swartz.

The general training objectives for the real world village training exercises include providing diplomatic security, differentiating between hostile and indigenous people, and egression from the crisis site. Every exercise focused on the efficient and systematic completion of several discrete tasks. These specific tasks are outlined below.

- I. Urban Movement
  - A. Security detail through village
  - B. Protection of diplomat
- II. Assessment and triage of wounded
  - A. Call for medivac
  - B. Recover wounded

## **I. Urban Movement**

### **A. Security Detail**

Example: SEALs are conducting a field interrogation of a prominent local diplomat when they become ambushed by RPG's and AK 47 fire.

Task Objectives: 1) Safely escort the diplomat through the village.

TTP: Tactic – Security detail; Technique – Leap Frog; Procedure – Pie off and pick up uncovered danger areas, clear obstacles and indigenous people use the buddy system

VR Group: Subjects showed good task organization and effectively secured a path for the diplomat protection element. All danger areas were identified and covered while the buddy system was properly executed. The detail cleared obstacles and controlled the tempo and movement of the elements. Subjects returned fire quickly and effectively while finding good cover. The egress route was secured and utilized with little confusion. All personnel were accounted for.

Discussion: Training officers were impressed with the performance of the VR group and indicated that subjects exhibited marked improvement after VR training. Specifically, training officers noted that the VR training improved execution speed and team cohesiveness in the real scenarios. Participants noted that the VR training helped them mentally prepare for the real world exercises. As a result of VR training, subjects knew what dangers to look for and where to position themselves if they encountered hostile fire. Lieutenant Blintz commented that this type of trainer is a "high value trainer that teaches threat recognition and avoidance."

### **B. Diplomat Security**

Example: SEALs are conducting a field interrogation of a prominent local diplomat when they become ambushed by RPG's and AK 47 fire.

Task Objectives: 1) Safely remove the diplomat from situation.

TTP: Tactic – Diplomatic security detail; Technique – Egress to vehicle piece while protecting the diplomat; Procedure – Cover diplomat on all sides with bodies and utilize the egress route.

VR Group: Subjects maintained military bearing once attacked and effectively secured and removed the diplomat. The security detail quickly employed the egress route and evacuated the crisis site.

Discussion: Training officers were impressed with the organization and efficiency of the VR groups in employing the egress route. Further analysis of this task will be completed after the evaluation of the non-VR group.

## **II. Assessment and Triage of Wounded**

### **A. Calling for Medivac**

Example: While teams are searching and securing a small Iraqi village, they encounter hostile fire and engage the enemy in a fire fight. During the operation, a soldier loses his leg from an RPG that exploded in a back street of the village.

Task Objective: 1) Call for a medivac; and 2) recover the wounded.

TTP: Tactic – Snatch and grab; Technique – Eliminate the threat with firepower and recover the wounded soldier; Procedure – Concentrate maximum firepower down range, assemble a recovery team, snatch and grab the wounded

VR Group: Subjects returned fire quickly. Personnel were able to locate and remove immediate threats without sustaining more casualties. The snatch and grab team worked quickly and found good cover. Subjects strategically placed themselves in the optimal position to recover the wounded.

Discussion: Findings suggest that VR training taught participants to find protected areas, recognize potential threats, and react to dangerous scenarios.



## USMC 13<sup>th</sup> Marine Expeditionary Unit (13th MEU)



The 13<sup>th</sup> MEU under the Command of Colonel James LaVine participated in VR and real world training at Strategic Operations. Their focus was Visit, Board, Search, and Seizure (VBSS) training as part of their pre-deployment work up. Subjects were 30 male volunteers out of 170 whose ages ranged from 18-35. Participants varied in combat experience, rank, and competence with video games. Subject's years of service ranged from less than 1 year to 15 years. The virtual ship was displayed using a Dell XPS laptop computer. Participants sat at a desk and used a computer keyboard and mouse to navigate the virtual ship for exactly ten minutes.

### MEU Training Transfer Exhibited in Ship Exercises

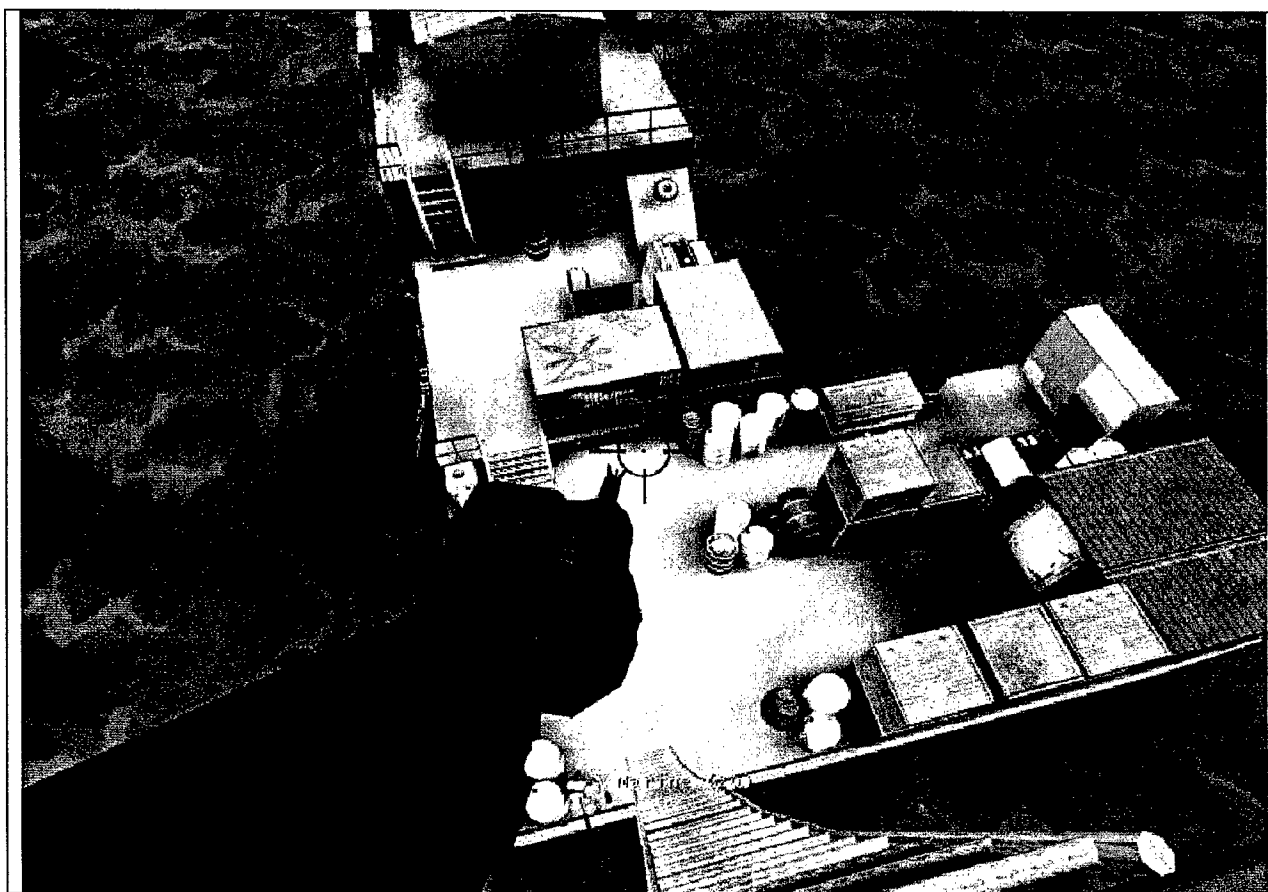


Figure 8

Participants were given instructions to take the virtual ship (Fig. 8) under U.S. custody and search for hidden cargo and contraband. Participants were shown how to navigate using a mouse and keyboard before beginning the exercise. Investigators observed and noted all tactical and mission specific maneuvers utilized or acquired in the virtual ship that could be transferred to performance in the real ship. After completing the virtual training, participants performed a similar exercise in a real world training scenario.

The real world training scenario was to: visit, board, search, and seize hidden cargo and contraband. The mission elements were: put a force on deck, take ship under U.S. custody, and search the vessel for hidden cargo and contraband as quickly and efficiently as possible. Two different techniques were employed to put a force on deck: fast rope from a helicopter 30 feet above deck, and caving ladders. The mechanical breaching technique used for all scenarios was a gas powered circular saw to breach one water tight door secured with five dogs (chains were used to simulate dogs).

Investigators along with training officers Captain Chris Hamn, Gunnery Sergeant Troy Olafson, and Gunnery Sergeant Brian Lively, who acted as Independent Assessors, observed the participants' performance during the real-life exercise from an observation tower above the real ship. Assessors evaluated the effects of virtual training on the real world exercises by recording improvements in real world performance of each participant and the squads as a whole. Upon completion of real world training, participant interviews were conducted and feedback was collected.

#### A. Fast rope from helicopter

**Task Objectives:** 1) Helicopter diversion; 2) Place snipers on helo; 3) Put a force on deck; 4) Secure the bridge; 5) Take ship under U.S. custody; 6) Breach and search vessel for precious cargo.

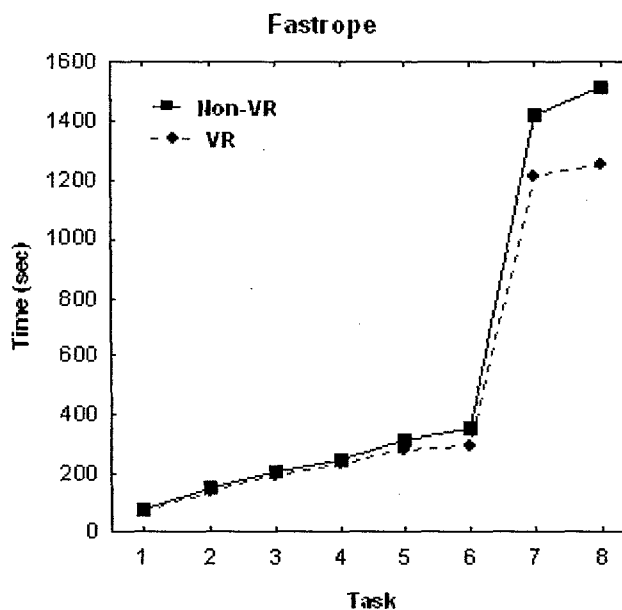
**Tactic, Technique, Procedure (TTP):** Tactic – Marine Expeditionary Unit; Technique – fast rope from helo, one on each side; Procedure – set up security element topside, conduct a bottom up assault on the bridge, breach and search vessel from the top down.

**VR Group Performance:** Subjects displayed outstanding task organization when deploying from the helicopter and setting up the security element. Personnel found good cover and quickly established a stronghold topside. The assault element assembled without confusion and quickly secured the bridge and took the ship under U.S. custody. There was good communication as to where the breach point was located and the proper tools needed. The breach team worked efficiently and breached the ship without any tactical errors. The ship was searched satisfactorily.

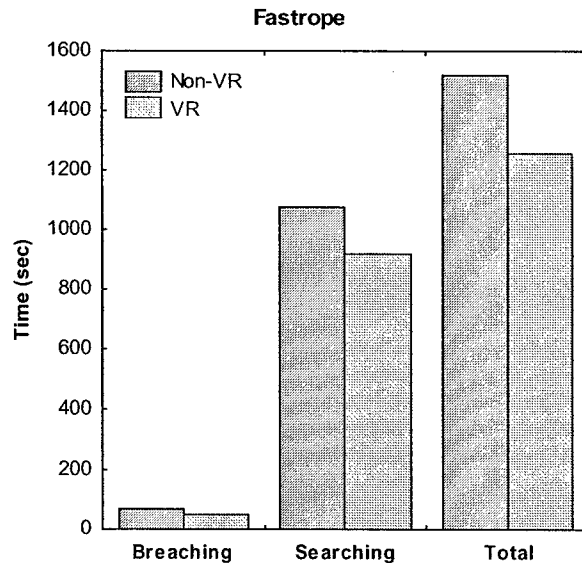
**Non-VR Group Performance:** Subjects were slow in setting up the security element and there was confusion as to when to assault the bridge. Personnel were unaware if they were part of the security element or assault element. There was poor communication in regards to the breach point location. Breaching took 20 seconds longer than the VR group and 152 seconds longer to satisfactorily search the ship.

**Discussion:** The VR group put a force on deck 10.7% faster, established security 5.3% faster, breached the ship 29.9% faster, and searched the ship 14.2% faster than the Non-VR trained group. Additionally, the VR group completed the mission 17.2% faster. Participants commented that the VR exposure aided in the mental preparation of assaulting the ship. The VR made participants more aware of the spatial layout topside, which allowed them to utilize this to their advantage when setting up security and assaulting the bridge. VR taught overall situational awareness and attention to detail.

Task Key	
1	force on deck
2	security established
3	bridge secure
4	start breaching
5	finish breaching
6	commence searching vessel
7	secure searching vessel
8	index







### *B. Caving Ladder*

**Task Objectives:** 1) Put 2 personnel topside; 2) Secure caving ladders topside; 3) Put a force on deck; 4) Secure the bridge; 5) Take ship into U.S. custody; 6) Breach and search vessel for hidden cargo and contraband.

**Tactic, Technique, Procedure (TTP):** Tactic – Marine Expeditionary Unit; Technique – caving ladders, two on port side of ship; Procedure – set up security element topside, conduct a bottom up assault on the bridge, breach and search vessel from the top down.

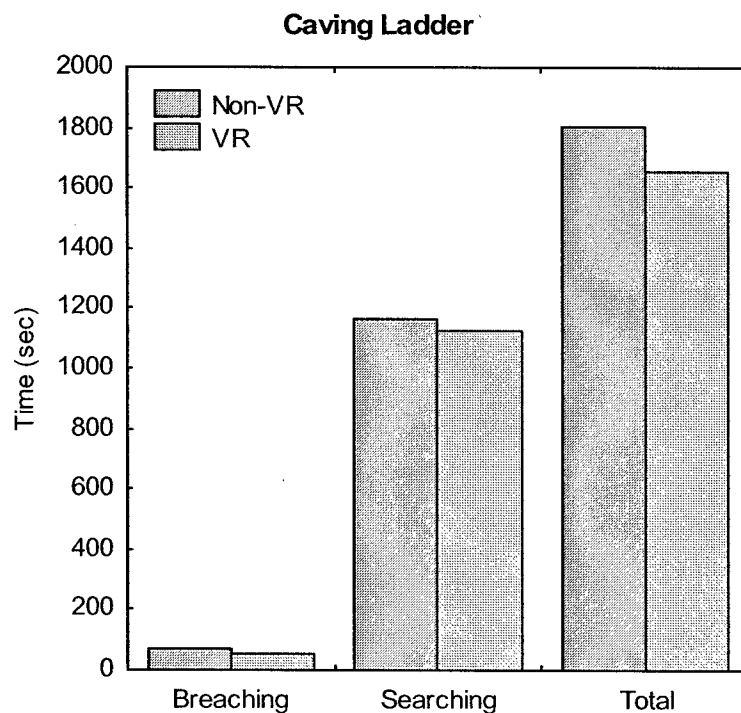
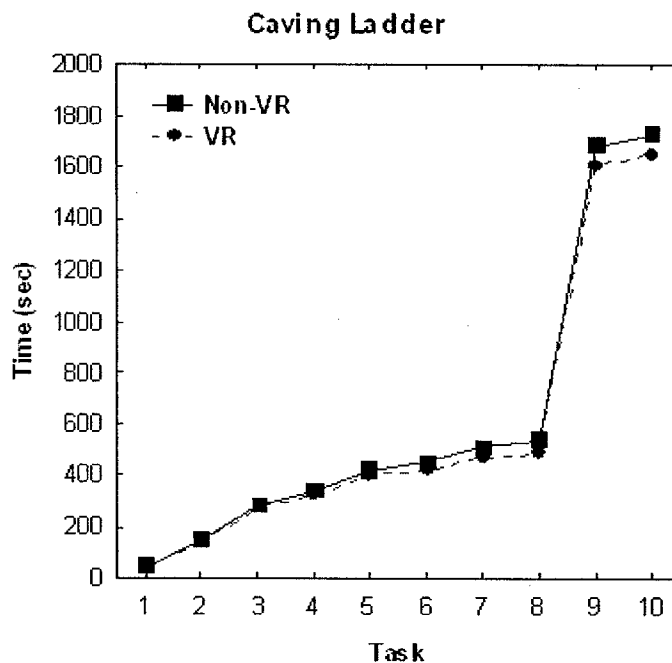
**VR Group Performance:** Subjects quickly and effectively secured the caving ladders topside. The security element was established optimally and the assault element flowed into the bottom up assault smoothly. The word “bridge secured” was passed clearly and the breaching team responded immediately breaching the ship in 52 seconds. The vessel was searched satisfactorily.

**Non-VR Group Performance:** Subjects took 14% more time to secure the caving ladders topside and 13.8% longer to put a force on deck. The assault element secured the bridge 5 seconds faster than the VR group but took significantly more time breaching and searching the vessel.

Upon further evaluation, we found that the VR trained group had never practiced nor executed this type of ship board assault. We believe this was a factor in the performance difference seen between groups. More importantly however was that the inexperienced VR trained group still outperformed the Non-VR trained group in 2 out of 3 tasks.

**Discussion:** Training officers were impressed with the speed and effectiveness the VR group displayed while securing the caving ladders topside, putting a force on deck, and establishing security. The VR gave the subjects a greater situational awareness resulting in an overall superior performance. Additionally, the VR taught spatial awareness as the VR group searched the ship and completed the mission faster than the Non-VR group.

Task Key	
1	2 personnel top-side
2	ladders secured
3	security established
4	force on deck
5	bridge secure
6	start breaching
7	finish breaching
8	commence searching vessel
9	secure searching vessel
10	index



### Coast Guard Training Transfer in Ship Exercises

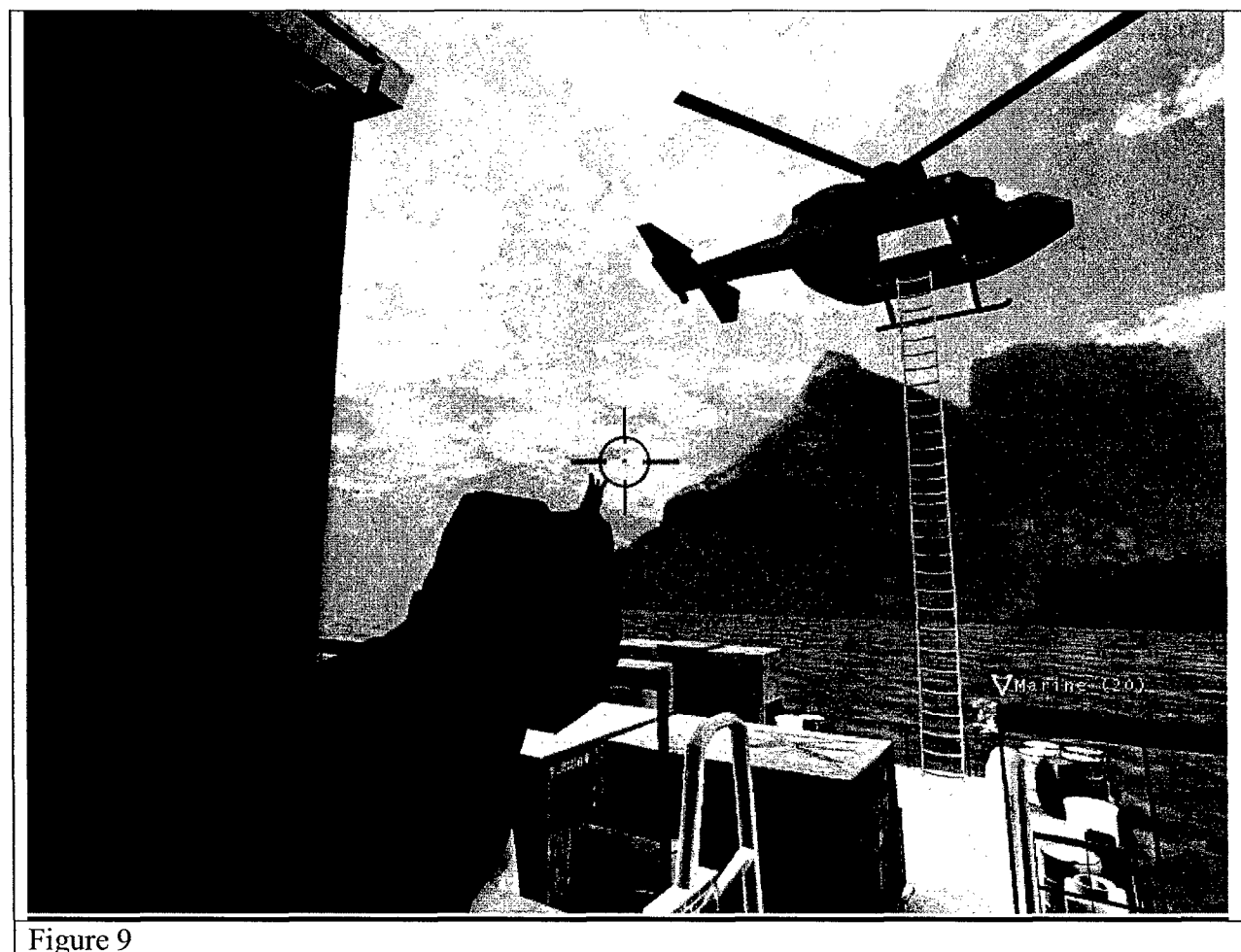


Figure 9

Participants navigated the virtual ship (Fig. 9) with enemies for approximately fifteen minutes (minimum VR exposure was 14 minutes and 42 seconds; maximum VR exposure was 15 minutes and 10 seconds) prior to real world training. Performance in the VR exercises was carefully recorded and subjective feedback was collected. After VR training, the VR group completed real world training exercises and their performance was observed via 9 real time video cameras placed throughout the ship. Commander Ogle and a research assistant reviewed the videotape and critically evaluated participants' performance. The VR group's performance was then compared to the performance of the non-VR group.

The general training objectives for the real world ship training exercises were to visit, board, search, and seizure. Every exercise focused on the efficient and systematic completion of several discrete tasks, which were observed and critically evaluated during each training scenario. These specific tasks are outlined below.

- I. Board the ship
  - A. Fast rope
  - B. Ladder
- II. Seize the ship
  - A. Take command of the control tower
  - B. Infiltrate the ship
  - C. Secure the ship
  - D. Conduct a detailed search of the ship

## **I. Board the Ship**

### *A. Fast Rope*

Example: The Coast Guard has stopped a larger ship at sea and needs to board the ship by fast roping on to it from a MH-68 helicopter.

Task Objectives: 1) Gain access to the ship using a fast rope and 2) secure the ship.

TTP: Tactic – Drug Interdiction Team; Technique – Fast rope onto the deck of the ship from MH-68 helicopter; Procedure – Deploy from a helicopter, one at a time, and secure the ship

VR Group: In general, subjects displayed no major tactical errors. There was good task organization on the helicopter and ship. Deployment of personnel went satisfactorily and efficiently.

Discussion: Commander Ogle noted that the teams were following procedure and doctrine more closely and accurately than non-VR-trained groups. This implies that subjects performed better at procedural tasks after the VR training. These findings also suggest that the VR training may have facilitated in improving the speed of learning in real world tasks.

### *B. Ladder*

Example: A ship has been stopped in port and a Coast Guard Drug Interdiction team must board and search the ship for drugs and contraband.

Task Objectives: 1) Board the ship using a ladder and 2) search the ship.

TTP: Tactic – Drug Interdiction Team; Technique – 3-man teams; Procedure – Board the ship via a ladder and conduct a detailed search of the ship's compartments from top to bottom

VR Group: Subjects displayed outstanding order and discipline when boarding the ship.

Discussion: Commander Ogle observed that the teams were quiet and moved with a purpose as they boarded the ship. He felt that the VR training was a good "warm up for coordination, agility, and accuracy," as the teams appeared more alert and executed procedures quickly and accurately.

## **II. Seize Ship**

### *A. Take the Control Tower*

Example: The team is onboard the ship and needs to secure the control tower.

Task Objectives: 1) Assault the control tower and 2) take command of the ship.

TTP: Tactic – Law Enforcement Detachment; Technique – 5-man teams; Procedure – Break off into a security and assault element and conduct a "bottom up" assault



VR Group: Subjects properly set up the security element for the “bottom up” assault. Teams broke off into the elements with good task organization and carried out the assault with few tactical errors. Generally, the assault element built up and maintained momentum as the control tower was secured.

Discussion: Subjects displayed sound tactics and outstanding task organization. Commander Ogle felt the VR training was a key element in the team’s high level of intensity and momentum. He was impressed with the speed and agility of the assault element as they navigated up the ladder to the control tower. Findings suggest that the VR training facilitated teamwork and task organization.

#### *B. Infiltrate the Ship*

Example: All personnel are onboard and need to infiltrate the ship, locate contraband, gather evidence, and locate and secure the scuttle valve before evidence is lost.

Task Objectives: 1) Secure the ship; 2) locate and secure the scuttle valve; and 3) conduct a detailed search of all the compartments.

TTP: Tactic – Law Enforcement Detachment; Technique – 5-man teams; Procedure – Break off into teams and secure the ship before conducting a detailed search of all the compartments

VR Group: Subjects exhibited a systematic search routine. The subjects were thorough and located all hidden compartments (100% accuracy). Subjects located all drugs and contraband with speed and accuracy. The entire ship was secured and searched in a systematic fashion. Subjects were able to locate the scuttle valve in just three (3) attempts.

Discussion: Commander Ogle noted that the VR group followed procedure closer than previous non-VR groups. Commander Ogle was impressed with the speed, accuracy, and force of action with which the VR subjects executed this task. Findings suggest that the VR training improved participants’ spatial awareness of the ship, which helped subjects search the compartments in a more detailed and systematic method. He was most impressed with the fact that the VR group only required 3 attempts to locate the scuttle valve. He commented that non-VR teams needed many more tries before locating the valve, thus demonstrating the effectiveness of the VR trainer.

#### *C. Secure the Ship*

Example: Internal security must be established and maintained while a detailed search of the ship is conducted.

Task Objectives: 1) Set up security and 2) establish communications.

TTP: Tactic – Internal security and communication element; Technique – 5-man teams; Procedure – Secure danger areas and establish communications, use buddy system

VR Group: Subjects located and covered all danger areas while providing cover for the search teams. Communication was established and maintained at an optimal level.

Discussion: Subjects in the VR group exhibited better spatial recognition and a better feel for the overall layout of the ship, compared to non-VR-trained groups. Data suggests that VR training taught subjects to locate danger areas and find cover better than groups without VR training.

#### *D. Detailed Search*

Example: The ship is secured and teams must conduct a detailed search of all compartments.

Task Objectives: 1) Conduct a detailed search of the entire ship and 2) maintain security.

TTP: Tactic – Search team; Technique – 5-man teams; collecting everything into a sea bag; Procedure – Search ship from top to bottom and collect items in a sea bag, touch everything

VR Group: In every exercise, subjects located all weapons caches, drugs, and contraband on board (100% accuracy). The search team was extremely detail oriented.

Discussion: Commander Ogle commented that the VR-trained subjects were more detailed in searching the ship’s compartments, compared to non-VR-trained groups. Findings suggest that the VR training taught subjects about the spatial layout of the ships compartments, which enabled them to locate concealed objects and identify potential hiding places more effectively.

Commander Ogle observed that the detachment was more aware and efficient, and displayed better tactics and fundamentals after the VR training. He noted that personnel were able to find the scuttle valve in only three attempts compared to previous times where it took many more. He further commented that the personnel are able to develop good timing and a very real sense of being on the ship through the VR. Additionally he felt that the VR would be a good “warm up for coordination, agility, and accuracy.” In post training interviews, participants noted that they felt more vigilant and aware of hidden compartments due to VR training. Another participant commented that when he encountered danger he was able to “find a way around it” from the previous VR training.



## USMC 1<sup>st</sup> Light Armored Reconnaissance Battalion (1<sup>st</sup> LAR)



The Alpha, Bravo, and Charlie (H&S) Companies of the 1<sup>st</sup> LAR under the command of Lieutenant Colonel Constantini participated in VR and real world training at Strategic Operations. One hundred fifty two (152) out of the four hundred (400) present participated in the study. Their focus was on military operations in urban terrain in the village and room clearing in the shoothouse (Fig. 10). They were midway through their pre-deployment work up.

### LAR Training Transfer Exhibited in Shoothouse Exercises



Figure 10

## Experiment I Video game VS. Real world

In this study, we asked the question of whether or not the action of playing a video game would affect the outcome of the performance in the real shoothouse and real village. There is some evidence in the literature that playing video games improves cognitive function and performance.

### *Method*

Sixty (60) subjects were broken into three (3) randomly assigned groups, 20 subjects per group. The video game group played Bejeweled 2 for ten (10) minutes before training in the shoothouse. Bejeweled 2 is a game where the player swaps adjacent gems to make sets of three matching gems. This is accomplished by moving and clicking the mouse. As you proceed through the game, gem patterns become progressively more difficult to recognize. The VR group trained in the virtual shoothouse for ten (10) minutes prior to entering the real shoothouse. The control group received no VR training before entering the shoothouse.

### *Subjects*

Subjects were 60 male volunteers whose ages ranged from 18-35. Participants varied in combat experience, rank, and competence with video games. Subject's years of service ranged from less than 1 year to 15 years.

### *Apparatus*

The video game and virtual shoothouse was displayed using a Dell XPS laptop computer. Participants sat at a desk and used a computer keyboard and mouse to play Bejeweled 2 and train in the virtual shoothouse for exactly ten (10) minutes.

### *VR Training*

Participants were not given any time to practice playing the video game or train in the virtual world.

### *Design and Procedure*

Participants in the video game group were given instructions to play the video game to the best of their abilities for ten (10) minutes. Researchers observed and noted the effectiveness of each player. Scores were recorded by how many sets of gems the participant could match up in ten minutes.

Participants in the VR group were tasked to enter and clear the virtual shoothouse utilizing proper tactics, techniques, and procedures. Researchers observed and noted all tactical and mission specific maneuvers utilized or acquired in the virtual shoothouse that could be transferred to performance in the real shoothouse.

The control group received no training before entering the real shoothouse.

Participants were tasked to conduct room clearing exercises in the real shoothouse. They were to execute 4-man entries utilizing the proper tactics, techniques, and procedures for a cordon knock. They entered a semi-permissive condition where escalation of force and initiative based tactics were heavily stressed.

Researchers observed the movements from a catwalk above the shoothouse, and timed the participants as they cleared the rooms.

Times and performance from the video game group were then compared to the times and performance of the no video game group (control group) and VR group.

### *Results*

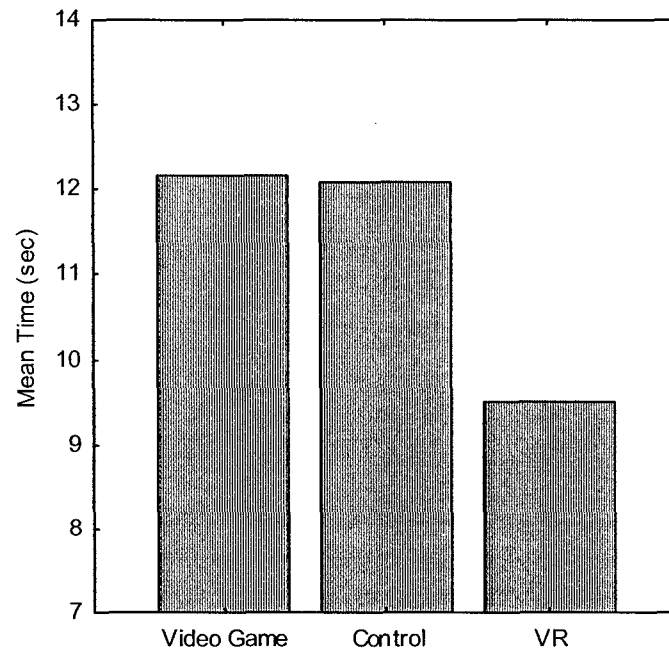
Task Objectives: 1) Knock on the door and politely remove the head of the household from the house 2) Conduct 4-man room clears

Tactic, Technique, Procedure (TTP): Tactic – cordon knock; Technique – 4-man entries; Procedure – knock on door, remove head of house hold, clear house

Results: The video game group took an average of 12.15 seconds to clear a room while the control group took an average of 12.07 seconds to clear the same room. This amounts to a .07 or .61% difference favoring the control group. As seen previously, the VR group took an average of 9.42 to clear the room.



**Discussion:** These data show a statistically insignificant change in performance based on playing video games. This implies that in order for video game based trainers to be effective, they must contain task relevant material. It is not enough to sit in front of a monitor and click and move the mouse. The participant must be actively engaged in task relevant exercises within the video simulation.



## Experiment II Laptop VS. CAVE

In this experiment, we wanted to see if the admittedly more immersive one walled CAVE environment was more effective in contributing to training transfer than the laptop computer.

### Method

A laptop group trained on the virtual shoothouse via laptop computer while a cave group trained on a one walled CAVE system before training in the real shoothouse. The control group received no training before entering the shoothouse. Their performances were observed, noted and compared.

### Subjects

Subjects were 60 male volunteers whose ages ranged from 18-35. The laptop, CAVE, and control groups were made up of 20 subjects randomly assigned to each group. Participants varied in combat experience, rank, and competence with video games. Subject's years of service ranged from less than 1 year to 15 years.

### Apparatus

For the laptop group, the virtual house was displayed using a Dell XPS laptop computer. Participants sat at a desk and used a computer keyboard and mouse to navigate the virtual house.

For the cave group, the virtual house was displayed using a projector and a one-walled CAVE system. Participants sat at a desk approximately 15 feet from the projector screen and used a computer keyboard and mouse to navigate the virtual shoothouse.

### VR Training

Participants were not exposed to virtual reality before entering the virtual house. In addition, participants were not given any time to train in the virtual world. The investigators demonstrated how to navigate through the world using a mouse and keyboard and how to jump, shoot the gun, and reload the weapon.





## Design and Procedure

The cave and laptop groups participated in the conditions independently. Participants were instructed to enter and clear the virtual house while protecting themselves from hostile fire. Both groups participated in the simulation for exactly ten minutes prior to entering the shoothouse.

Participants were then tasked to conduct room clearing exercises in the real shoothouse. They were to execute 4-man entries utilizing the proper tactics, techniques, and procedures for a cordon knock. They entered a semi-permissive condition where escalation of force and initiative based tactics were heavily stressed.

Researchers observed the movements from a catwalk above the shoothouse, and timed the participants as they cleared the rooms.

Times and performance of the laptop group were then compared to the times and performance of the cave and control group.

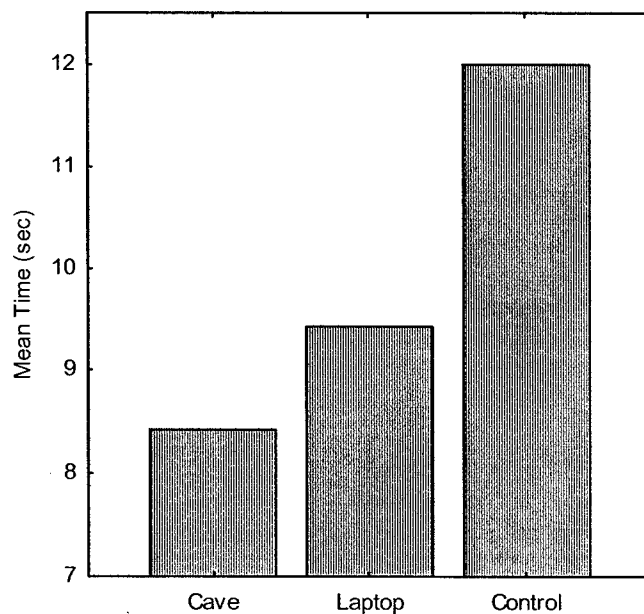
## Results

**Task Objectives:** 1) Knock on the door and politely remove the head of the household from the house 2) Conduct 4-man room clears

**Tactic, Technique, Procedure (TTP):** Tactic – cordon knock; Technique – 4-man entries; Procedure – knock on door, remove head of house hold, clear house

**Results:** The cave group took an average of 8.42 seconds to conduct a 4-man room clear. The laptop group took an average of 9.42 seconds to conduct a 4-man room clear of the same room. This calculates to exactly 1 second or 10.61% faster room clearing for the cave group. The control group averaged 12.07 seconds.

**Discussion:** One (1) second is a very significant amount of time in this context. Based on after action interviews, participants commented on how immersive and stimulating the CAVE system was. The life size dimensions and projection must be impacting the synthesis of information within the participant. Furthermore, participants of the cave group commented that once in the real shoothouse, they felt as though they had “already been there.” However, the laptop computer did provide a significant improvement in performance. There is an opportunity here to tailor the type of virtual training environment to the task.



### Experiment III Laptop VS. Number of runs in the shoothouse

In this experiment, we wanted to compare training performance in the virtual environment vs. training performance after conducting multiple runs in the real environment.

#### *Method*

A VR group trained on the virtual shoothouse via laptop computer before entering the shoothouse. A control group was monitored over four (4) runs in the shoothouse with out any virtual training. The group's performances were compared.

#### *Subjects*

Subjects were 32 male volunteers whose ages ranged from 18-35. The VR group was made up of 16 subjects as was the control group. Subjects were randomly assigned to each condition. Participants varied in combat experience, rank, and competence with video games. Subject's years of service ranged from less than 1 year to 15 years.

#### *Apparatus*

For the VR group, the virtual house was displayed using a Dell XPS laptop computer. Participants sat at a desk and used the computers keyboard and mouse to navigate the virtual house for exactly ten (10) minutes.

#### *Design and Procedure*

The VR group was tasked to enter and clear the virtual shoothouse while protecting themselves from hostile fire. Participants were then tasked to conduct room clearing exercises in the real shoothouse. They were to execute 4-man entries utilizing the proper tactics, techniques, and procedures for a cordon knock. They entered a semi-permissive condition where escalation of force and initiative based tactics were heavily stressed. Researchers observed the movements from a catwalk above the shoothouse, and timed the participants as they cleared the rooms.

Times and performance of the VR group's one run was then compared to the times and performance of the control group over its four runs.

#### *Results*

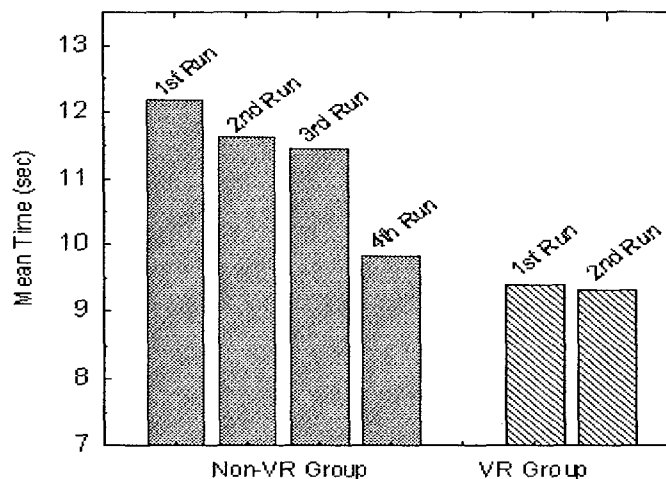
Task Objectives: 1) Knock on the door and politely remove the head of the household from the house 2) Conduct 4-man room clears

Tactic, Technique, Procedure (TTP): Tactic – cordon knock; Technique – 4-man entries; Procedure – knock on door, remove head of house hold, clear house

Results: The VR group took an average of 9.42 seconds to conduct a 4-man entry on their first run. The control groups' times from 1<sup>st</sup> to 4<sup>th</sup> were 12.19, 11.62, 11.46, and 9.85 respectively. The first run by the VR group was 2.77 seconds (22.73%) faster than the 1<sup>st</sup> run by the control group and .43 seconds (4.32%) faster than the 4<sup>th</sup> run by the control group.

Discussion: The laptop is an effective tool to efficiently teach mission specific behaviors. Ten minutes on the laptop produced the same result as 4 runs and an hour in the shoothouse. This result was similar to the result reported by Commander Ogle for performance for Coast Guard personnel in the virtual ship. Essentially we see that virtual training can reduce real world training by 75% in terms of training sessions.





## **Lessons Learned**

### ***Training Transfer in Shootouse Exercises***

- Subjects more effectively used walls for protection
- Subjects located cover quicker
- Subjects demonstrated an increased awareness of what was behind them
- Subjects exhibited enhanced spatial awareness, which improved speed and coordination of movements
- Subjects demonstrated an improved recognition of dangers
- Subjects responded to threats more effectively
- Subjects developed a cognitive map of the area, which helped them complete their mission more efficiently
- Subjects identified hidden areas more accurately
- Subjects exhibited an increased ability to adapt to unknown and/or challenging situations
- Subjects exhibited an improved ability to anticipate movements of their teammates
- Subjects executed tasks more consistently and systematically

### ***Training Transfer in Iraqi Village Exercises***

- Subjects exhibited improved execution speed and faster completion times of tasks
- Subjects located cover quicker
- Subjects remained concealed and protected for longer periods
- Subjects were more alert to potential traps placed by enemies
- Subjects demonstrated better positioning and personnel placement
- Subjects recognized and reacted to threats more effectively

### ***Training Transfer in Ship Exercises***

- Subjects performed better at procedural tasks
- Subjects learned new concepts more quickly in the real world
- Subjects located hidden compartments quicker
- Subjects located the scuttle valve in fewer attempts

## **Conclusion**

The laptop simulator has proven to be an effective and efficient method of training. Skills obtained and polished in the trainer not only enhance mission specific behaviors but readily generalize to many other skills and behaviors. The simulator has proven effective for the cognitive and associative phases of learning.

The system is an inexpensive, low cost tool that leverages commercial products. The final product is a system that can effectively reproduce lifelike environments that can be delivered via: laptop computer, personal computer, CAVE system, or head mounted display.



## **Future Plans**

Based on our quantitative and qualitative observations, the Virtual Reality Medical Center has developed new concepts for future stimulators and trainers for the military. Our research and feedback from the many participants have shaped new ideas and ways of thinking when creating the next generation of simulators.

Our psychologists will design a training methodology based on cognitive psychology, which will automate a response through repetition, while incrementally increasing the workload and decreasing the response time. There will be a heavy emphasis placed on procedural information within the game, as research has shown that what is done procedurally is learned best and most resistant to forgetting. We have the ability to work with heavily experienced individuals that can integrate lessons from recent combat missions to reproduce actual field conditions. In addition to enhancing instructional and motivational aspects, we would employ a widely popular multiplayer online role-playing aspect and test it in a real world environment.

Not only is there a high demand for small unit, multi-user simulators, but this aspect would significantly increase motivation, relevance to game play, and presentation modality. From a central server the VRMC would be able to simultaneously place numerous personnel into virtual worlds and take on different roles as they carry out a complete mission. Whole SEAL teams would be able to work in concert and rehearse missions from the initiation to completion. Personnel through the Chain of Command would be able to communicate to everyone involved verbally through headsets, and visually on the screen.

Personnel preparing to deploy to Iraq would play the assault roles while experienced personnel would play the role of insurgents and civilians. Support personnel would be able to call in close air support, medevac, etc. There will be a robust list of locations that covers the globe, so personnel in Japan can train for deployments to Liberia. The engine will also give an assessment of the assault or battle plan (if security was optimal, wrong type of assault, etc). Additionally the engine would replay the scenario so that everyone involved could analyze and take in valuable lessons learned.

With the high demand for small unit team training; 3-walled CAVE systems and the ability to use your service weapon within the simulator, training can be brought to a new level and optimized for less than 10k.

### **Itemized Man-Hours and Costs (accumulated totals)**

Direct labor: \$372,650

Travel: \$8,108

Subcontract: \$42,343

Other direct: \$3,090

Total: \$426,191

### **Contract Deliveries Status**

R&D Status Report sent monthly

Funds & Man-Hour Expenditure Report sent monthly

Semi-annual Technical Report sent every six months

### **Report Preparer**

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